Draft Acceptance Plan for MQXB

Michael J. Lamm
Phil Schlabach
Tanaji Sen
June 14, 2001

The acceptance plan is a "checklist" which specifies a set of tests on the magnet performed during various stages of the construction. The checklist would have a brief explanation of the test, with reference to an external writeups which would explain the test in detail. Also included would be the acceptable test result. The results of the tests are presented in summary on a form, with reference to full writeups (or a web site) and would be compared with the criteria outlined in the acceptance plan. A draft of this checklist is shown below along with the acceptance form (table 1).

Acceptance Plan

1) Mechanical Twist and Straightness
   Reference: table 4 LHC-LQX-ES-0002
   Requirement: Less than 1 mR/5 m twist, 100 μm/5 m straightness
   Procedure:Traveler
   Procedure summary: Warm MQXB is laid on granite table. For twist, Using leveling fixture keyed to Skin alignment key, determine angle of keys relative gravity. For straightness, estimate maximum bow from a straight edge at the horizontal position.
2) Room Temperature Instrumentation and bus work
   Reference: Section 3.3 LHC-LQX-ES-0002
   Requirement: Each wire and bus properly labeled, proper gauge, not shorted to ground or other wire.
   Procedure:Traveler
   Procedure summary: As part of the assembly procedure, each wire will be checked against wire list for the above attributes.
3) Room Temperature hipot
   Reference: 3.4 Voltage limits LHC-LQX-ES-0002
   Requirement: In air or bagged in dry N2, coil to ground/heater and heater to ground/coil can withstand 5 kV voltage difference without breakdown or excessive leakage current. Prior to quadrant busing, voltage from coil quadrant to coil quadrant can withstand 3 kV voltage difference. Coil ringing will be performed on whole coil to look for turn to turn breakdown.
   Procedure: Traveler

Procedure summary: Tests performed prior to magnet exposure to Helium gas. Magnet bagged in dry N2. Follow hipot safety procedure outlined in traveler. Quadrant to quadrant (prior to quadrant bussing), 3 kV, Coil: short heater to ground, 5 kV coil relative to ground. Leakage current less than 5 μA and no breakover. Similar permutation for heater to coil/ground combination. For ringing test, follow safety procedure outlined in traveler. Look for quandrant to quadrant asymmetries and otherwise evidence of electrical breakdown.

4) Cold instrumentation check out
   Reference: Section 3.3 LHC-LQX-ES-0002
   Requirement: On test stand, instrumentation wires have proper continuity, no shorts to ground
   Procedure: Pre test run plan
   Procedure summary: All instrumentation wires are checked on the test stand for proper continuity. Resistance to ground is measured.
5) Cold heater checkout
   Reference: Section 3.2 LHC-LQX-ES-0002
   Requirements: Heater circuits have proper resistance, quenches all quadrants
   Procedure: Test plan
   Procedure summary: Measure cold resistance. Value equal to 10 ohms. With no magnet excitation current discharge heaters with heater firing units. Using data logger signals verify time contants, no arc over to ground. At 3000 amps, initiate quench with heaters (or manual trip with extraction circuit delay) Verify that there is resistive voltage in all 4 quadrants within 150 ms of heater firing. At 670 amps verify that heater is develop resistive voltage in coils.
6) Cold electrical hipot
   Reference: 3.4 Voltage limits LHC-LQX-ES-0002
   Requirement: On test stand, in liquid helium, coil to ground/heater and heater to ground/coil can withstand 1.4 kV voltage difference without breakdown or excessive leakage current
   Procedure: Pre test run plan
   Procedure summary: Follow hipot safety procedure outlined in pretest. Coil: short heater to ground, 1.4 kV coil relative to ground. Leakage current less than 5 μA and no breakover. Similar permutation for heater
7) No quenching up to and including operating gradient (after training)
   Reference: Table 2 LHC-LQX-ES-0002
   Requirement: Magnet reaches 230 T/m during first 1.9 K thermal cycle, reaches 220 T/m on 2nd and successive thermal cycles without quenching
   Procedure: Run Plan
   Procedure summary: During first superfluid test in LMQXB assembly, magnet reaches 230 T/m (12850 amps) as a result of training program. On second thermal cycle the magnet is ramped to 220 T/m (12290 A) without a spontaneous quench
8) Peak temperature and peak voltage to ground.
   Reference: Section 3.2 LHC-LQX-ES-0002
   Requirement: As a result of a quench, hot spot temperature less than 400 K, Voltage to ground less than 450V.
   Procedure: Run plan

Procedure summary: Execute full energy manual trip. At 12 kA (~215 T/m) Power supply is phased back, both heater circuits are energized. No external extraction circuits. Determine the quench integral from the on line data loggers. MIITs value less than 15. If 1/8 taps are available, determine that voltage across each 1/8 is less than 450 volts.

9) No training degradation after full energy deposition trip (see above)
   Reference: CERN-KEK-US collaboration minutes
   Requirement: Magnet reaches 220 T/m after full energy deposition quench
   Procedure: Run Plan
   Procedure summary: In superfluid, magnet energy is dissipated through a "full energy deposition quench" This can be accomplished by a 12kA manual trip of the system. The power supply is phased off, the heaters are fired. There is no energy extraction circuit. Then magnet is ramped to 220 T/m without quench.
10) Integral Field
   Reference: Table 1 LHC-LQX-ES-0002
   Requirement: Integral field variation is less than 1.5×10^{-3}
   Procedure: Run Plan
   Procedure Summary: Using single stretched wire determine the integral G.dl. at 6 kA excitation current. Compare results to previous magnets.
11) Transfer function
   Reference: Table 2, Figure 3 LHC-LQX-ES-0002
   Requirement: Gradient /excitation current correlation
   Procedure: Run plan
   Procedure summary: During cold testing of LMQXB assembly, measure the field strength using the single stretch wire system, at 11.3 kA or 205 T/m. Current to reach 205 T/m should be within 100 amps of Functional specification value.
12) Integrated Cold Harmonics
   Reference: Table 3 LHC-LQX-ES-0002 and Integrated Cold Harmonics Acceptance Table
   Requirements: Harmonics fall within acceptance table limits.
   Procedure: Run plan, attached table 2
   Procedure summary: During cold testing, measure harmonics during a continuous ramp cycle up to 12 kA. The up-down average harmonics up to the b10,a10 at 6 kA must fall within acceptance limits. Limits are defined as db + 3 s(b)

Acceptance Plan
Magnet Name

	Criterion	Short Description	Reference	Accept?	Comment
1	Mechanical twist and straightness	Tolerance of 1 mR/5m in twist, 100 μm/5 m in straightness	Traveler		
2	Room temp. Instrumentation and bus	Room temperature check of each instrumentation wire. Each wire properly labelled, goes to appropriate location, not shorted to ground, not shorted to another wire	Traveler		
3	Room Temperature Hipot	Room temp. N2 gas 5kV coil to ground	Traveler		
4	Cold Instrumentation	On test stand, each wire is checked for continuity and shorts to ground	MTF checkout procedure		
5	Cold heater checkout	Heaters adequately protect magnet	MTF checkout procedure		
6	Cold electrical Hipot	In liquid helium Coil to ground, Coil to heater, heater to coil 1.4 kV	MTF checkout procedure		
7	After training, magnet reaches 220 T/m without quench	On first thermal cycle magnet is trained to 12850 amps.On second thermal cycle, magnet reaches 12300 amps without quench	Run plan		
8	Peak temp. and voltage to ground	On second thermal cycle, manual trip QDC,measurem MIITs compare to expected value (corres to <400K. Volts less than 450 V to ground (only do with 1/8 coil taps)	Run plan		
9	No training degredation after full eneryg deposition	On second thermal cycle, after 12kA trip with heater firings, magnet reaches 12300 amps without quench	Run plan		
10	Integral Field	AT 6kA determine integral G*dl should be within 0.15 percent of average	Run plan		
11	Transfer function	Proper transfer function at 205 T/m	Run plan		
12	Integral Harmonics	At 6 kaA cold measure field harmonics compare to harmonics acceptance table	Run plan, harmonics table		

Table 1 MQXB Acceptance Form

n	acceptance band	
	low	high
b3	-1.66	1.66
b4	-1.25	1.25
b5	-0.65	0.65
b6	-0.76	1.18
b7	-0.12	0.12
b8	-0.08	0.08
b9	-0.04	0.04
b10	-0.05	0.04
a3	-1.34	1.34
a4	-1.29	1.29
a5	-0.65	0.65
a6	-0.22	0.17
a7	-0.11	0.11
a8	-0.05	0.05
a9	-0.04	0.04
a10	-0.04	0.04

Table 2 Acceptable range of integral harmonics at 6 kA for MQBX (Harmonics Acceptance Table)